UH... WE'VE BEEN WALKING THE WRONG DIRECTION FOR ALMOST AN HOUR...I NEED TO GET HOME! I HAVE A TEST TOMMORROW!

PANT, PANT

DON'T WORRY. YOU'LL BE BACK IN TIME FOR YOUR TEST. ANYWAY, WE'RE HERE!

WE WALKED AN HOUR TO SEE A MUD PUDDLE?

MUCH MORE THAN THAT!

AGH!

WHAT THE...?

WHY AM I FLOATING ON A DISC?

SO YOU DON'T FALL FOR ALL INFINITY?

OH, OK.

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WITHOUT WATER, LIFE CAN NOT EXIST.
THE QUESTION IS.. WHY WATER?

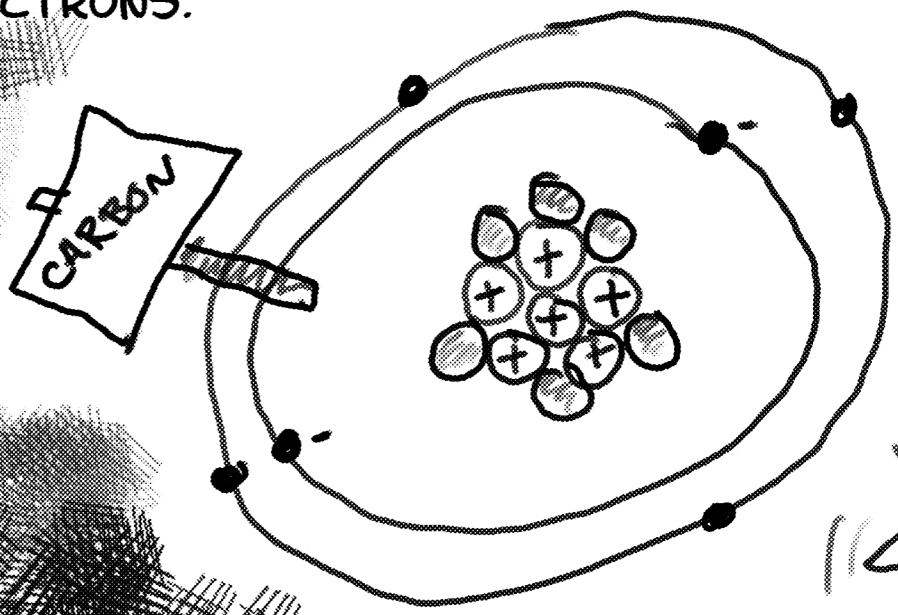
IN ORDER TO ANSWER THIS THIS QUESTION, WE NEED TO UNDERSTAND A LITTLE BIT OF BASIC CHEMISTRY FIRST.

ATOMS: ATOMS ARE THE SMALLEST UNIT OF AN ELEMENT. IN BIOLOGY, THERE ARE ONLY A HANDFUL OF ELEMENTS THAT WE CARE ABOUT:

SULFUR, PHOSPHORUS, OXYGEN, NITROGEN, CARBON AND HYDROGEN (SPONCH) MAKE UP 99% OF LIVING THINGS.

HERE - LET'S TAKE A LOOK AT AN ATOM UP CLOSE:

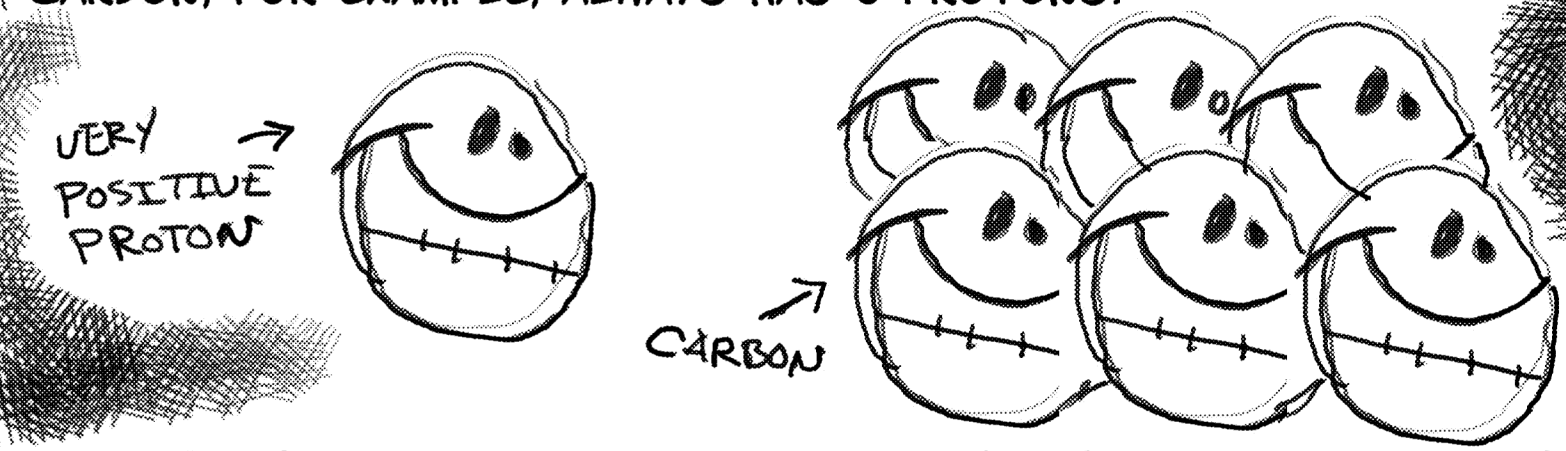
THIS IS CARBON, THE MOST IMPORTANT ELEMENT FOR LIFE. IT IS MADE UP OF THREE PARTS: PROTONS, NEUTRONS AND ELECTRONS.



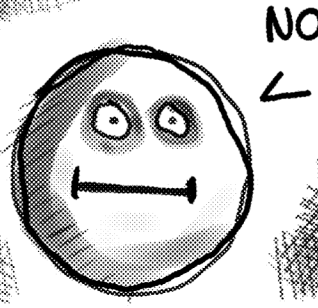
= PROTON
= NEUTRON
= ELECTRON

DISC OUT OF CONTROL! GONNA PUKE!

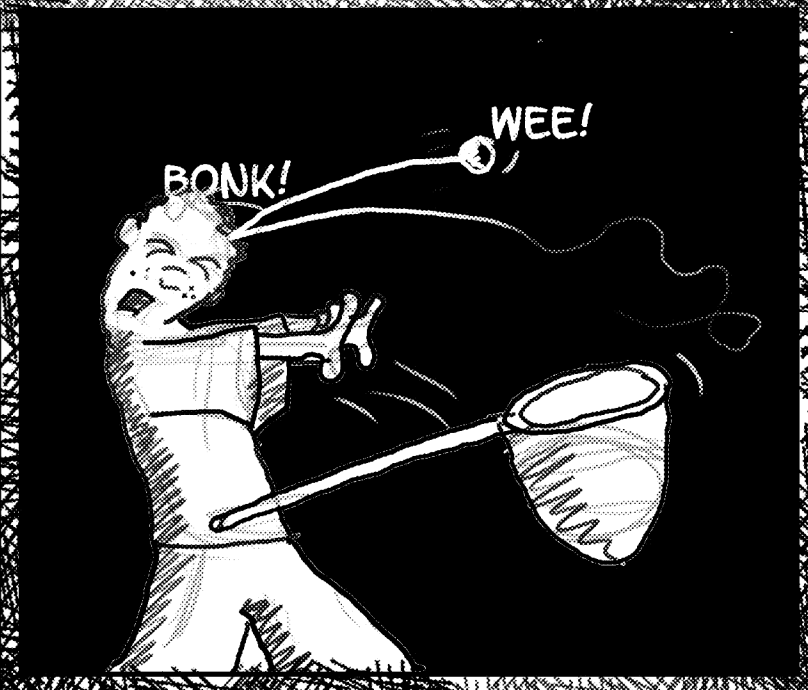
PROTONS HAVE A POSITIVE CHARGE, JUST LIKE THE PLUS END OF A BATTERY. THEY HANG OUT IN THE NUCLEUS, IN THE CENTER OF THE ATOM. THE NUMBER OF PROTONS IN AN ATOM DEFINES THE ELEMENT CARBON, FOR EXAMPLE, ALWAYS HAS 6 PROTONS.



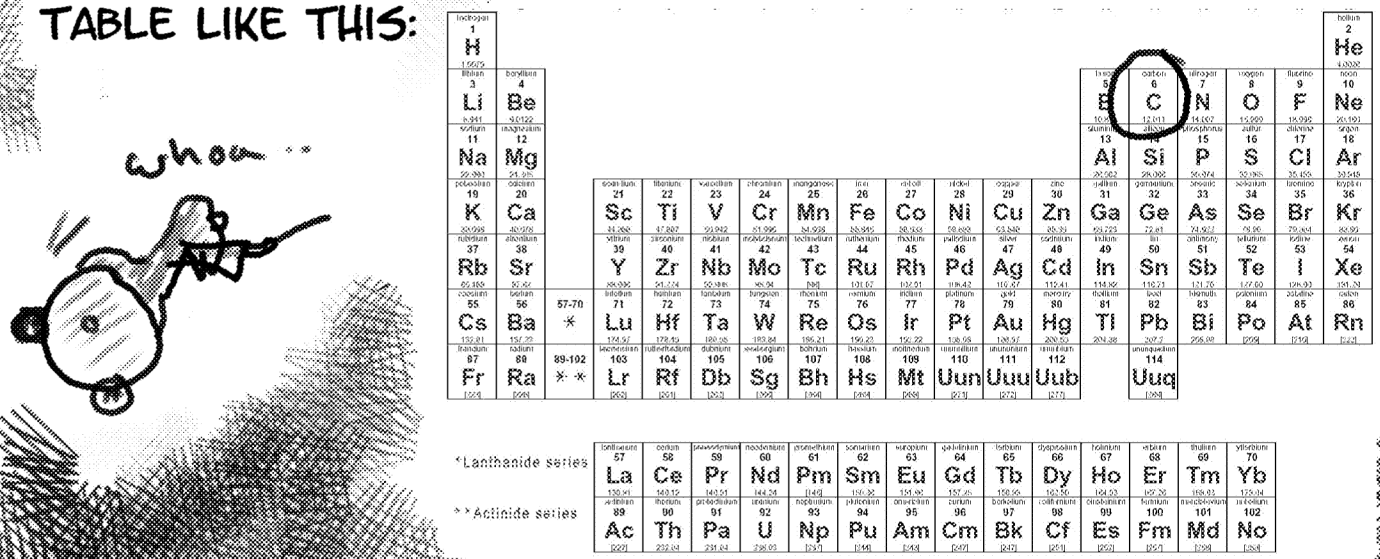
ALSO IN THE NUCLEUS ARE NEUTRONS. THEY HAVE ABOUT AS MUCH MASS AS PROTONS, BUT THEY DON'T HAVE A CHARGE. THE NUMBER OF NEUTRONS CAN VARY FROM ATOM TO ATOM. MORE ON THAT LATER



LASTLY WE HAVE ELECTRONS. THEY ARE HYPERACTIVE LITTLE BUGGERS THAT ORBIT AROUND THE NUCLEUS. THEY HAVE A NEGATIVE CHARGE, BUT VIRTUALLY NO MASS... MAKES THEM VERY HARD TO CATCH!



YOU CAN TELL SOME THINGS ABOUT AN ATOM BY LOOKING A PERIODIC TABLE LIKE THIS:



1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57-70 *	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89-102 **	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Uun	111 Uuu	112 Uub		114 Uuq				

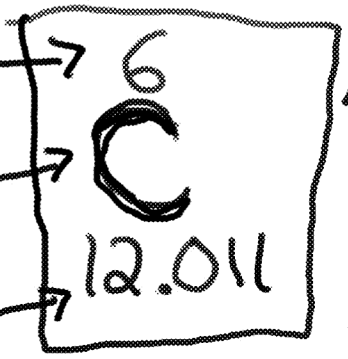
*Lanthanide series	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb
**Actinide series	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No

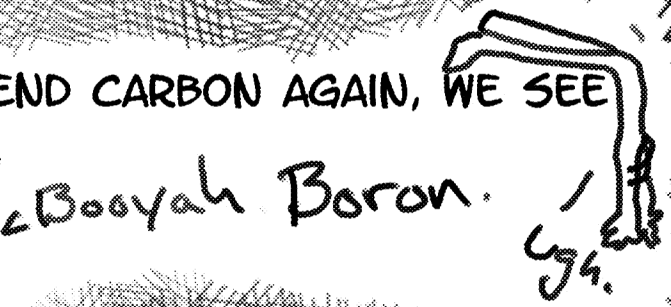
IF WE LOOK SPECIFICALLY AT OUR FRIEND CARBON AGAIN, WE SEE 3 THINGS:

ATOMIC NUMBER

ATOMIC SYMBOL

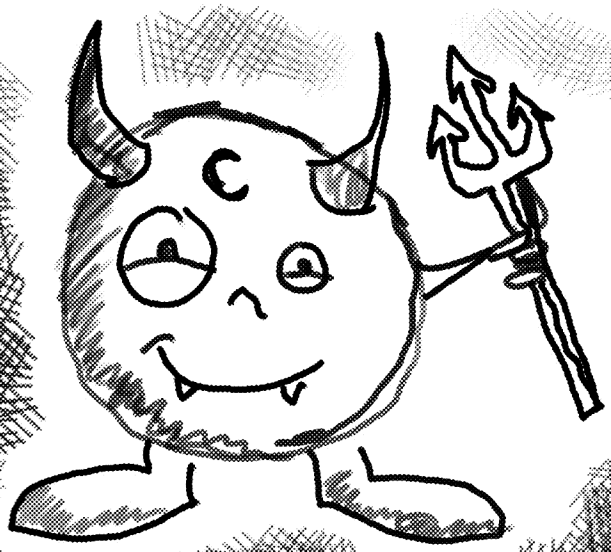
ATOMIC MASS



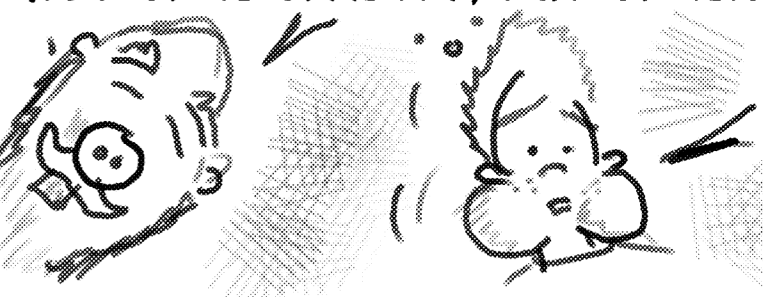


ATOMIC NUMBER IS HOW MANY PROTONS THAT ELEMENT HAS. CARBON IN THIS CASE HAS 6. THE ATOMIC SYMBOL IS JUST HOW IT IS WRITTEN. LASTLY, WE HAVE ATOMIC MASS, WHICH IS JUST THE NUMBER OF PROTONS AND NEUTRONS ADDED TOGETHER. SO CARBON USUALLY HAS 6 PROTONS AND 6 NEUTRONS. FOR UNCHARGED ATOMS, WE CAN ASSUME THERE ARE AS MANY ELECTRONS AS PROTONS (6 AGAIN)

6 Protons
6 Neutrons
6 electrons...
umm...

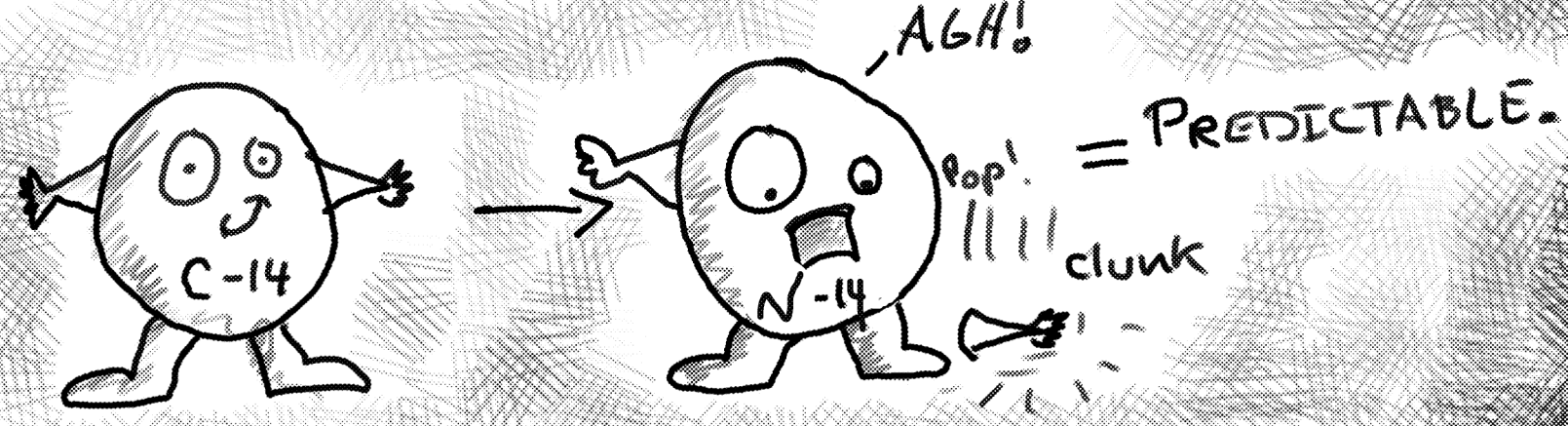


NOW, YOU MIGHT HAVE NOTICED THAT CARBON HAS AN ATOMIC MASS NOT OF 12 EXACTLY, BUT OF 12.011.

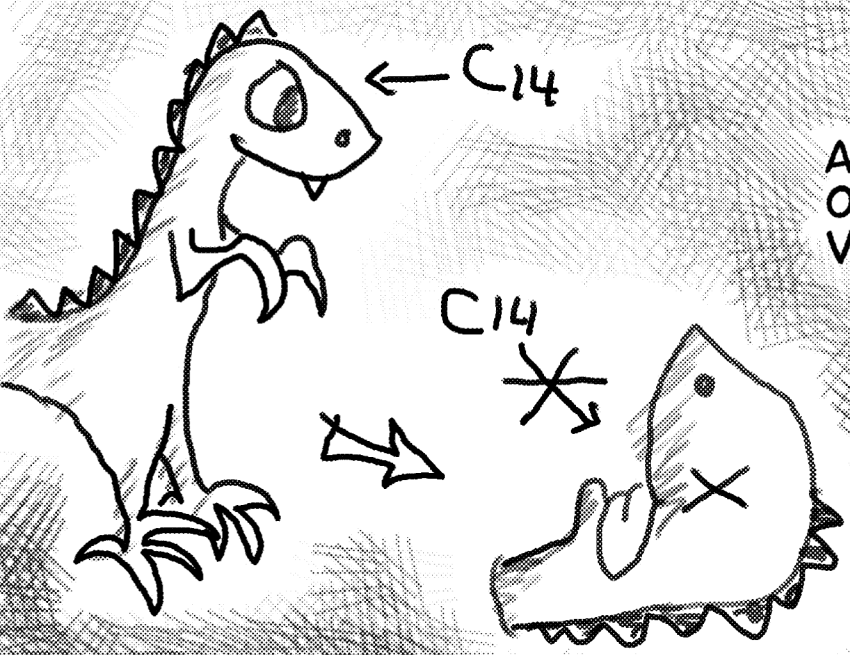


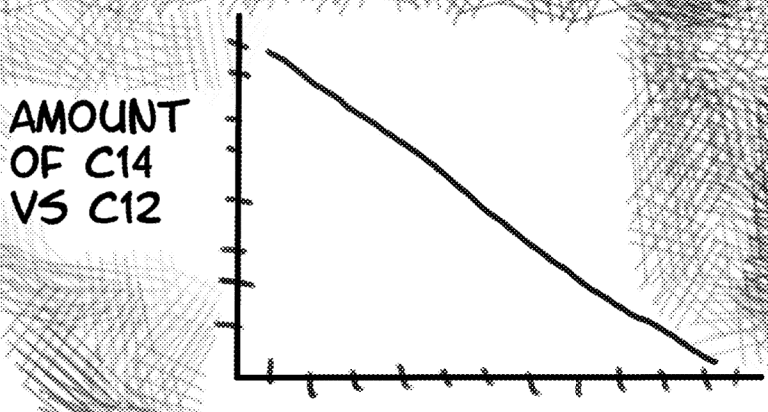
I WOULD HAVE... HAD I NOT JUST THROWN UP ON THE PERIODIC TABLE.

OH. WELL ANYWAY, IT ISN'T EXACTLY 12 BECAUSE IT IS AN AVERAGE MASS OF ALL THE ATOMS OF CARBON KNOWN. SOME OF THESE ATOMS HAVE GREATER OR FEWER NUMBERS OF NEUTRONS. THESE ARE KNOWN AS ISOTOPES, AND THEY ARE USUALLY UNSTABLE AND FALL APART AT A PREDICTABLE RATE.



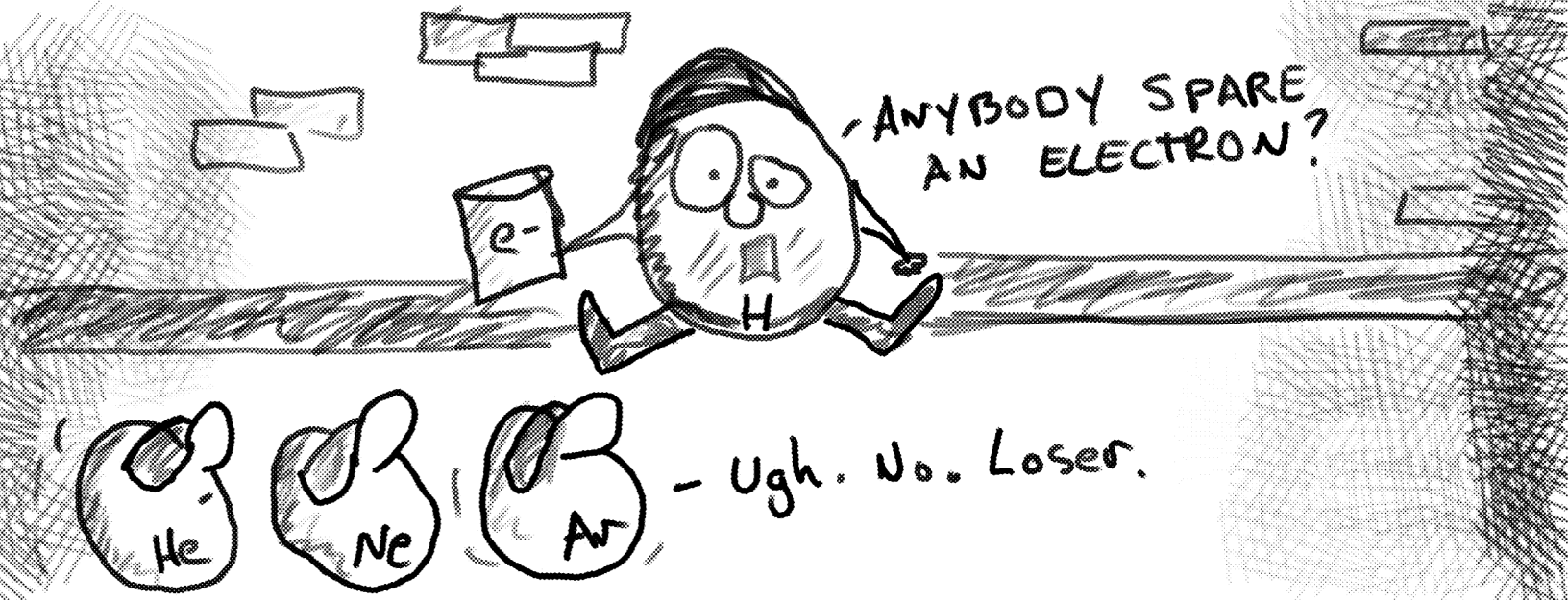
LIVING THINGS TEND TO TAKE IN LOTS OF A PARTICULAR ISOTOPE CALLED CARBON 14 (HAS 2 EXTRA NEUTRONS). WHEN THEY DIE, THAT CARBON 14 CEASES TO BE TAKEN IN, AND WHAT IS LEFT STARTS TO FALL APART AT A PREDICTABLE RATE. THIS ALLOWS US TO CARBON DATE THINGS THAT WERE ONCE ALIVE TO TELL WHEN THEY DIED.



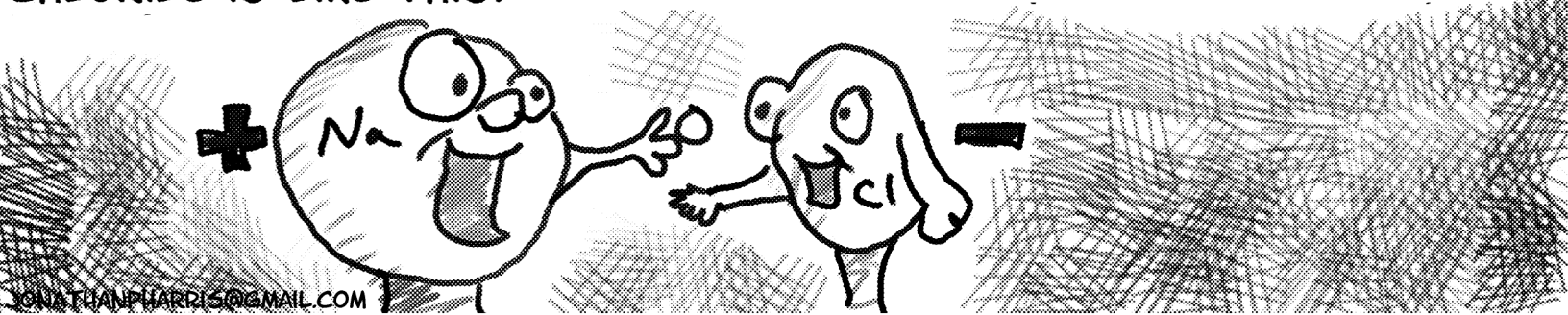


SO HOW THEN DO ATOMS STICK TOGETHER TO FORM MOLECULES? WELL, I'M GLAD I ASKED MYSELF THAT. YOU SEE, MOST ATOMS AREN'T 100% HAPPY WITH THEMSELVES. THEY ARE LOOKING FOR SOMETHING, SPECIFICALLY EITHER TO GAIN OR LOSE SOME ELECTRONS.

EACH ELEMENT WANTS TO GAIN OR LOSE A CERTAIN NUMBER OF ELECTRONS. THE NOTABLE EXCEPTION BEING THOSE SNOOTY, UPPITY NOBLE GASES IN THE RIGHT HAND COLUMN OF THE PERIODIC TABLE. THEY HAVE ALL THE ELECTRONS THEY WANT, SO THEY DON'T HANG OUT WITH ANYBODY ELSE.



NOW, IF AN ATOM THAT REALLY WANTS AN ELECTRON MEETS UP WITH AN ATOM THAT REALLY WANTS TO GET RID OF AN ELECTRON, THEN THEY FORM WHAT IS CALLED AN IONIC BOND. ONE OF THE MOLECULES BECOMES NEGATIVELY CHARGED (GAINED AN ELECTRON) AND THE OTHER BECOMES POSITIVELY CHARGED (LOST). TABLE SALT, OR SODIUM CHLORIDE IS LIKE THIS.



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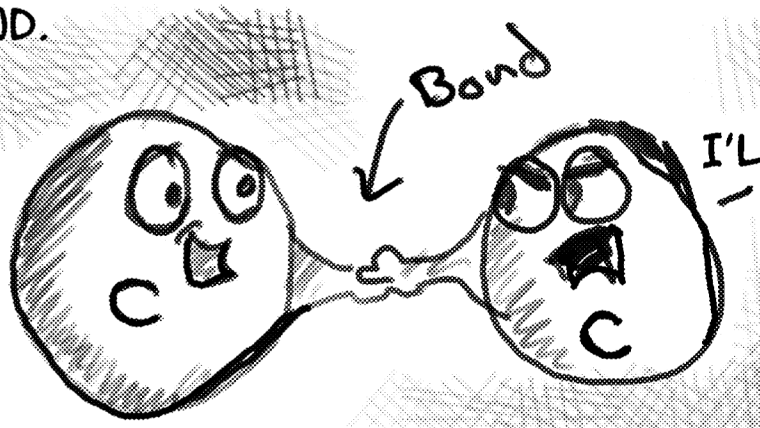
NOW, IF TWO ATOMS WHO BOTH WANT ELECTRONS THE SAME AMOUNT MEET UP, SAY TWO CARBON ATOMS, THEN THEY AGREE TO SHARE AN ELECTRON, SO THEY ESSENTIALLY BOTH GET 1. THIS IS CALLED A COVALENT BOND.



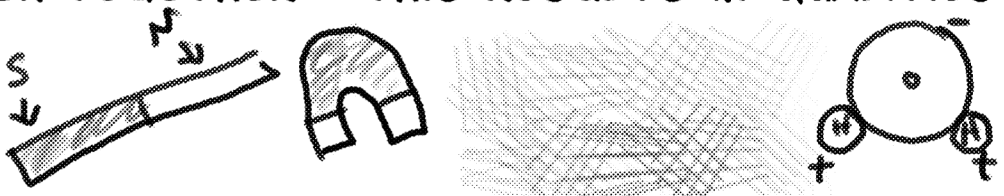
CAN I SHARE YOUR PORSCHE TOO?

Ed. Note: Atoms don't have cars... unless it's a neon! hoooo!

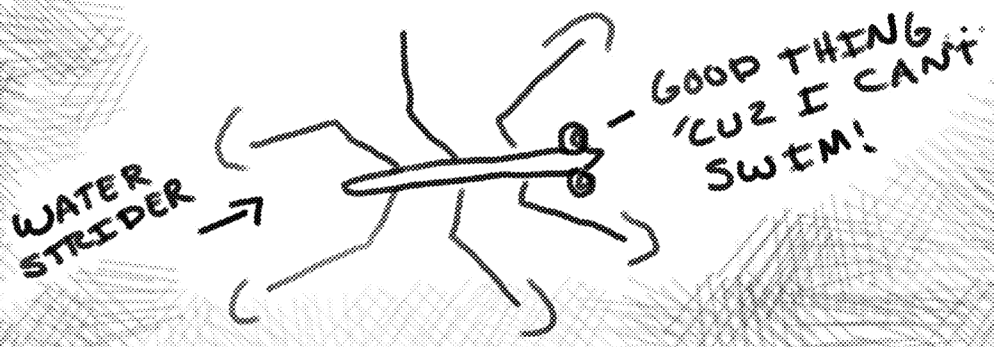
OK, SAME SCENARIO, BUT THIS TIME, ONE OF THE TWO ATOMS IS KIND OF A BULLY. LIKE OXYGEN FOR INSTANCE. OXYGEN REALLY LIKES ELECTRONS, AND HYDROGEN IS KIND OF A PUSHOVER. SO EVEN THOUGH THEY ARE COVALENTLY BONDED (SHARING) THE OXYGEN HOGS THE ELECTRONS A LITTLE MORE THAN THE HYDROGENS, SO IT IS SLIGHTLY NEGATIVE, WHILE THE HYDROGENS ARE SLIGHTLY POSITIVE.

WHY IS THIS IMPORTANT? THIS LITTLE MOLECULAR BONDING QUIRK MAKES LIFE POSSIBLE. IT GIVES WATER ALL THE QUALITIES NECESSARY FOR IT TO BE THE BASIS FOR LIFE ON EARTH. LETS LOOK CLOSER AT WATER...

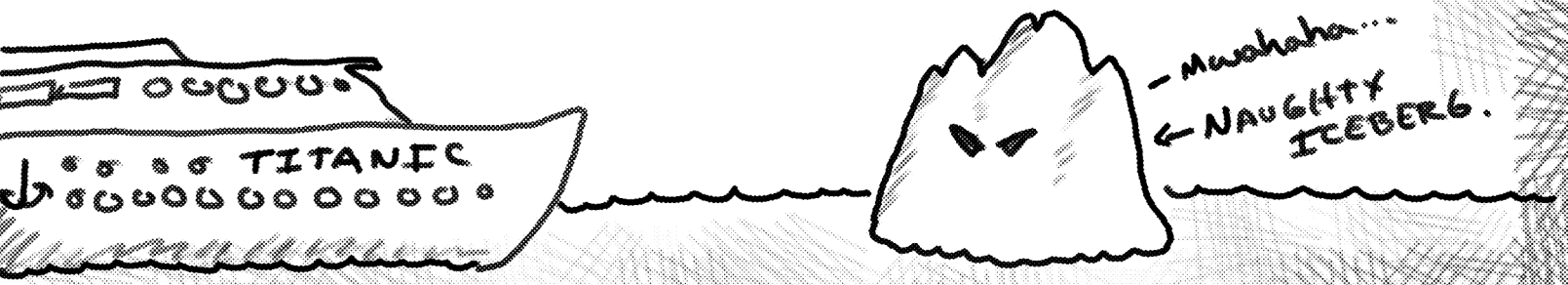
BECAUSE OF THESE SLIGHTLY POSITIVE AND SLIGHTLY NEGATIVE ENDS TO WATER, WE CALL IT A POLAR MOLECULE - AS IN IT HAS POLES, JUST LIKE A MAGNET. AND JUST LIKE MAGNETS, WATER MOLECULES STICK TOGETHER - THIS RESULTS IN QUALITIES LIKE:



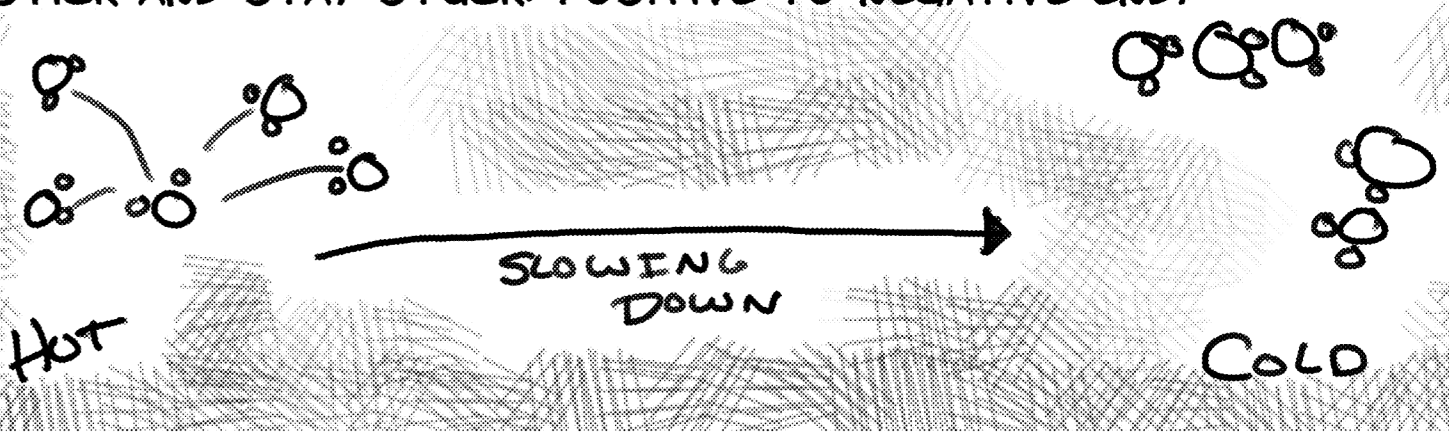
SURFACE TENSION! OR THE IDEA THAT WATER MOLECULES STICK TOGETHER - THIS IS ALSO CALLED COHESION



NOW, ORDINARILY WHEN A MOLECULE COOLS FROM A LIQUID TO A SOLID, IT BECOMES MORE DENSE (MORE WEIGHT PER VOLUME) BUT YOU KNOW FROM EXPERIENCE THAT ICE FLOATS - WHY?

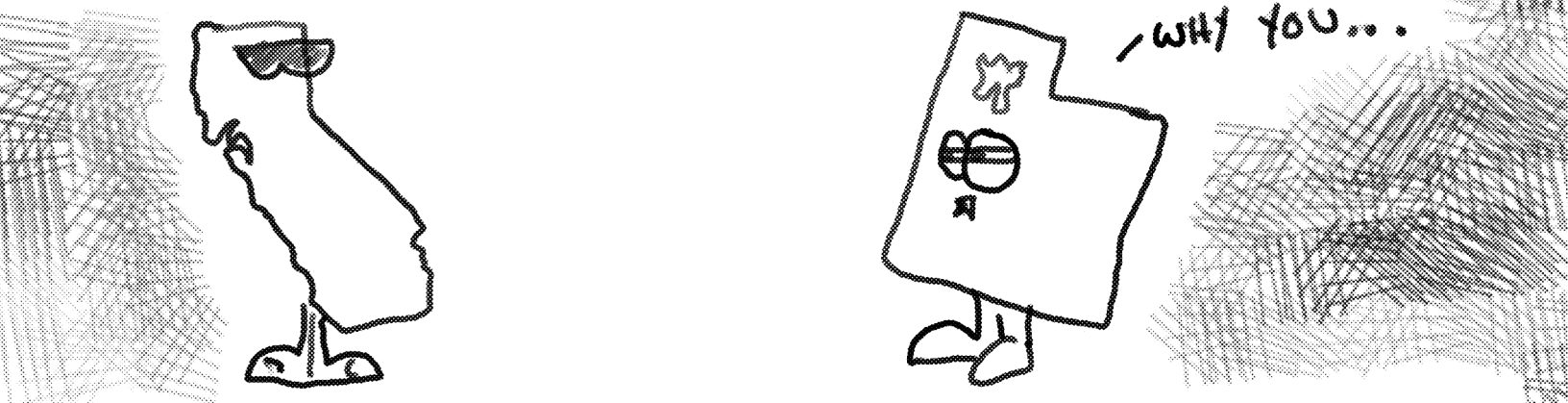


AS WATER MOLECULES COOL DOWN, THEY SLOW DOWN. WHEN THEY ARE WARM(LIQUID), THEY HAVE LOTS OF ENERGY-ALTHOUGH THEY STICK TO EACH OTHER BRIEFLY, THEY QUICKLY BOUNCE BACK. BUT! AS THEY SLOW DOWN, THEY STOP BOUNCING AND START TO STICK AND STAY STUCK: POSITIVE TO NEGATIVE END.

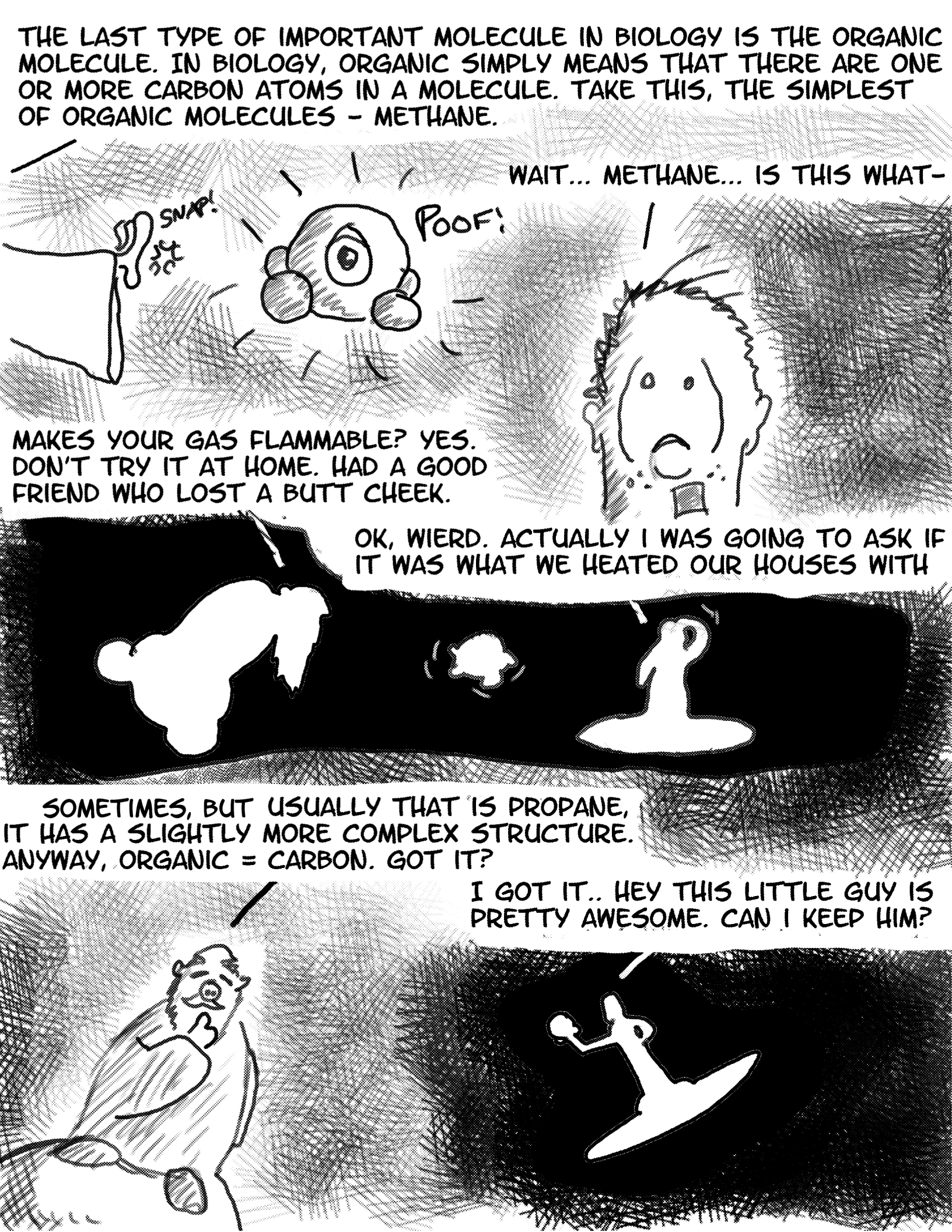


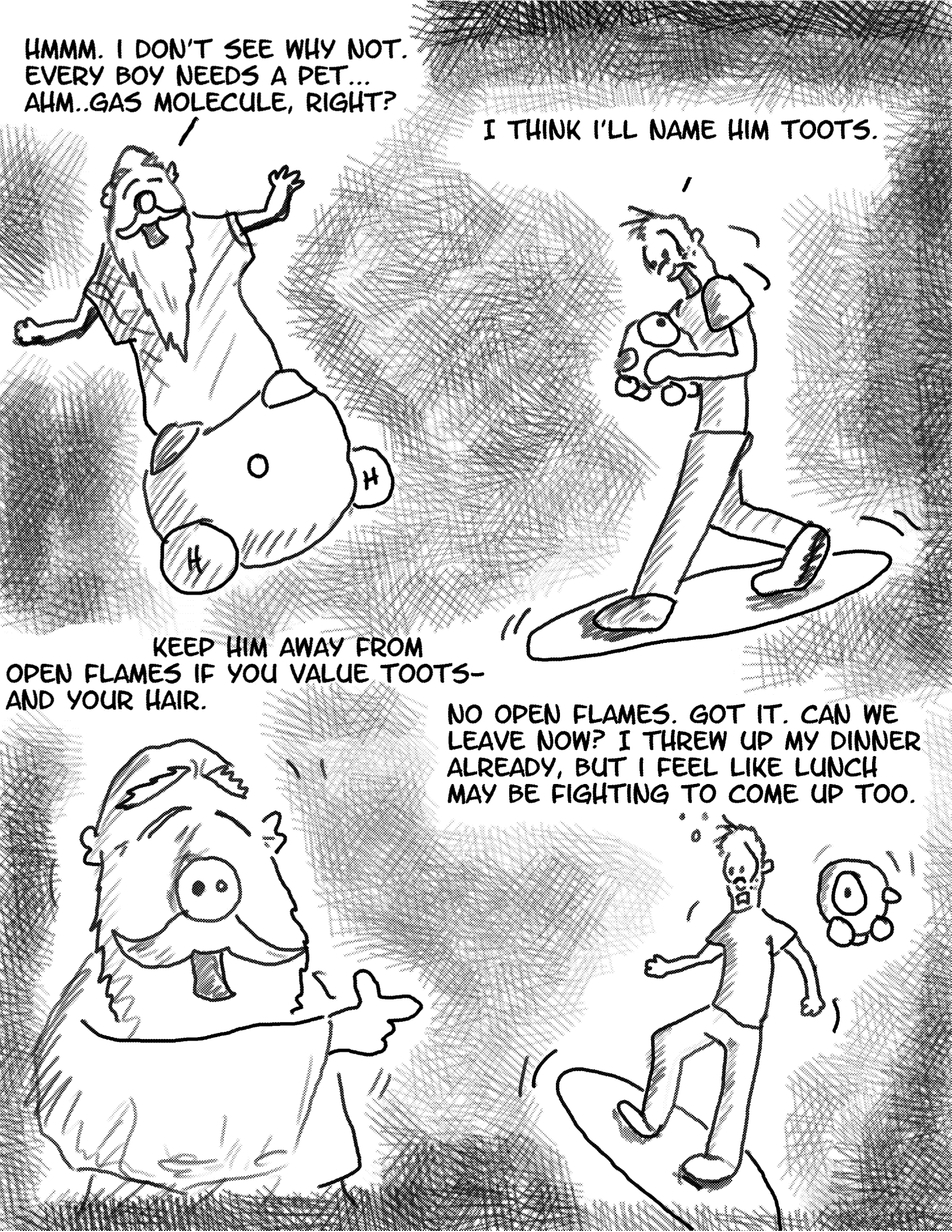
AS MORE AND MORE WATER MOLECULES STICK TOGETHER, THEY FORM A CRYSTAL STRUCTURE (CALLED A LATTICE) THAT IS LESS DENSE THAN LIQUID WATER. THIS IS WHY ICE FLOATS! THIS IS IMPORTANT, BECAUSE WITHOUT THE INSULATING LAYER OF ICE IN THE WINTER TIME, ALL OUR LAKES AND OCEANS WOULD FREEZE SOLID. AND THAT WOULD BE A BUMMER. 'CUZ WE'D BE DEAD.

ALONG THE SAME LINES, BECAUSE OF ALL IN THE INTERACTIONS BETWEEN WATER MOLECULES, WATER HOLDS IN HEAT VERY WELL. THIS IS WHY COASTAL CITIES ALWAYS HAVE MORE MODERATE CLIMATES THAN SAY...UTAH. MORE WATER = MORE HEAT AT NIGHT AND MORE COOL IN THE DAYTIME! WITHOUT ALL OF OUR WATER ON EARTH, WE WOULD HAVE HUGE TEMPERATURE FLUCTUATIONS. THAT TOO, WOULD BE AN EARTH KILLING BUMMER.

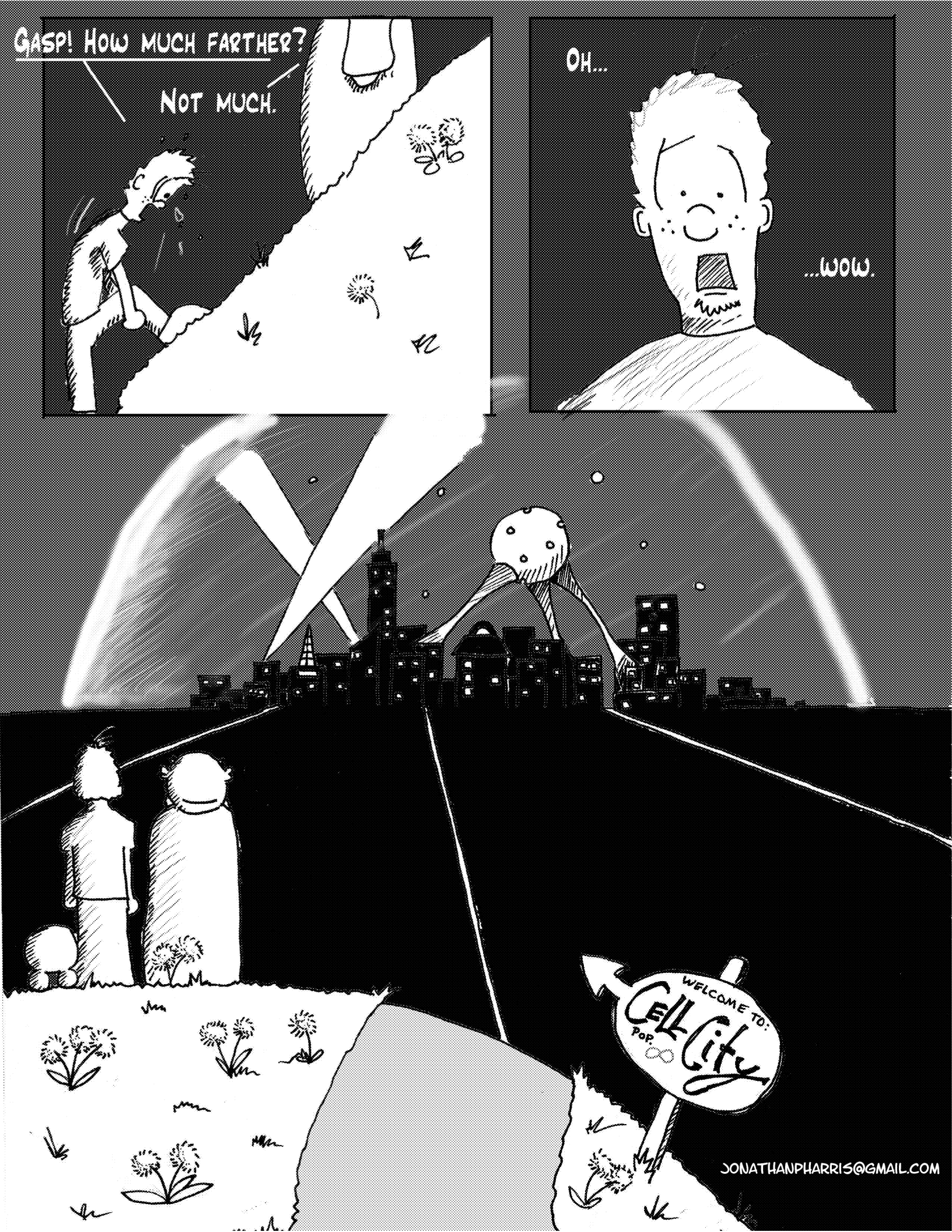


THE LAST REASON WATER IS SO IMPORTANT IS IT DISSOLVES STUFF VERY WELL (GOOD SOLVENT)- WHICH IS IMPORTANT FOR YOUR INNER WORKINGS. YOUR BODY AND CELLS HAVE TO CONSTANTLY MOVE STUFF AROUND. WATER IS HOW WE DO IT.


THE LAST TYPE OF IMPORTANT MOLECULE IN BIOLOGY IS THE ORGANIC MOLECULE. IN BIOLOGY, ORGANIC SIMPLY MEANS THAT THERE ARE ONE OR MORE CARBON ATOMS IN A MOLECULE. TAKE THIS, THE SIMPLEST OF ORGANIC MOLECULES - METHANE.
SNAP!
POOF!
WAIT... METHANE... IS THIS WHAT-
MAKES YOUR GAS FLAMMABLE? YES. DON'T TRY IT AT HOME. HAD A GOOD FRIEND WHO LOST A BUTT CHEEK.
OK, WIERD. ACTUALLY I WAS GOING TO ASK IF IT WAS WHAT WE HEATED OUR HOUSES WITH
SOMETIMES, BUT USUALLY THAT IS PROPANE, IT HAS A SLIGHTLY MORE COMPLEX STRUCTURE. ANYWAY, ORGANIC = CARBON. GOT IT?
I GOT IT.. HEY THIS LITTLE GUY IS PRETTY AWESOME. CAN I KEEP HIM?


HMMM. I DON'T SEE WHY NOT. EVERY BOY NEEDS A PET... AHM..GAS MOLECULE, RIGHT?
O
H
H
I THINK I'LL NAME HIM TOOTS.
KEEP HIM AWAY FROM OPEN FLAMES IF YOU VALUE TOOTS- AND YOUR HAIR.
NO OPEN FLAMES. GOT IT. CAN WE LEAVE NOW? I THREW UP MY DINNER ALREADY, BUT I FEEL LIKE LUNCH MAY BE FIGHTING TO COME UP TOO.


AND NOW I'M STANDING IN A MUD PUDDLE AGAIN. THIS NIGHT COULD NOT GET ANY INSANER.
MORE INSANE.
WHAT? YOU GONNA TUTOR ME IN ENGLISH NOW TOO?
JUST SAYIN'. ANYWAY, WE NEED TO GET MOVING TO GET TO CELL CITY IN TIME.
IN TIME FOR WHAT?
FOR THE NEXT PHASE OF YOUR LESSONS.
ON WHAT?
WELL... NOT GRAMMAR RULES THATS FOR SURE.
HEY... UH.. WAIT UP!


GASP! HOW MUCH FARTHER?
NOT MUCH.
OH...
...WOW.
WELCOME TO:
CELL CITY
POP. ∞
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REVIEW

1. AN ATOM, OR THE SMALLEST PART OF AN ELEMENT, IS MOSTLY EMPTY SPACE. IN FACT, IF WE MADE AN ATOM THE SIZE OF A FOOTBALL STADIUM, THE NUCLEUS WOULD BE ABOUT THE SIZE OF A MARBLE SITTING IN THE CENTER, WITH A CLOUD OF WHERE ELECTRONS MIGHT BE BUZZING AROUND IT. DRAW AN ATOM WITH 2 PROTONS AND 2 ELECTRONS BELOW. IT DOESN'T NEED TO BE TO SCALE. LABEL THE PARTS.

2. IF THE ATOMIC WEIGHT OF OUR ATOM IS 4, HOW MANY NEUTRONS WOULD WE NEED TO ADD?

3. WHAT ELEMENT HAVE WE CREATED?

4. POTASSIUM (K) HAS AN ELECTRONEGATIVITY OF .82. ELECTRONEGAVITY IS A MEASURE OF HOW MUCH AN ELEMENT "WANTS" ELECTRONS AND RANGES FROM ABOUT .7-3.8
IF WE COMBINED POTASSIUM WITH CHLORINE (ELECTRONEGATIVITY OF 3.16), WHAT TYPE OF BOND DO YOU THINK WOULD FORM? WHY?

5. WHAT ARE 2 OF THE PROPERTIES OF WATER THAT MAKE IT SO IMPORTANT FOR LIFE? WHY DOES IT HAVE THESE PROPERTIES?